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Potential and limitation of straight vegetable oils as engine fuel – An Indian perspective

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ABSTRACT

Due to rapid price increase in petroleum fuels, there is a growing demand for the search for sustainable, environment friendly and cost effective alternative substitute renewable fuel. Out of various available sources straight vegetable oils (SVOs) from edible oil and non-edible oil resources abundantly available in India are selected. Five edible and four non-edible selected SVOSs are analysed on the basis of composition of fatty acids. Oxidation Stability Index and cold flow properties are computed and SVOs are graded for biodiesel production. The result found that SVOs in order of decreasing OSI are Castor > Mahua > Neem > Karanja can be recommended as potential feed stocks for biodiesel production while other SVOs are not due to their instability but may require considerable effort to make the fuel stable. CP and CFPP of edible SVOs in decreasing order are found: Castor > Rape seed > canola > Soya bean while non-edible SVOs in decreasing order are Mahua > Neem > Karanja > Jatropha > Soybean indicating that there is a need to improve the cold flow properties using additives. Out of all SVOs the Castor oil has highest OSI and good cold flow properties and recommended as the best SVO for biodiesel production.

Contents

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1. Introduction

The world is confronted with the crises of fossil fuel depletion and environmental degradation. The indiscriminate extraction and consumption of fossil fuels coupled with serious environment degradation has led to the fast depletion of finite and highly concentrated fossil resources all over the world [1]. India imports more than 80% of petroleum crude and is putting heavy burden on exchequers. The situation can be improved by developing alternative biofuels like biodiesel and bioethanol as substitute of petroleum diesel and gasoline respectively. The biodiesel can be produced from renewable feedstock such as edible and non-edible oils [1,2]. The edible oils are used to meet the demand of food and more than 50% of total edible oil consumption is still imported in India and therefore there is no possibility of diverting edible oils for biodiesel production. The attention is then diverted to non-edible resources. Lots of research is available worldwide on the use of straight vegetable oils (SVOs) as engine fuel as substitute of petroleum diesel [3]. SVOs being renewable, are widely available from a variety of sources, with low sulphur contents close to zero, and hence cause less environmental damage than diesel. Altin et al. [4] found SVOs to have high energy contents and most require some processing to assure safe use in internal combustion engines. Some of these oils have already been evaluated as substitutes for diesel fuels. Ramadhas et al. [5] reported that SVOs can be directly mixed with diesel to operate the engines. Agarwal et al. [6] reported that the non-edible vegetable oils like *Jatropha, Pongamia*, *linseed, mahua* and *rice bran* oil are potential feed stocks for biodiesel production. But the main obstacle in using SVOs as fuel is its poor oxidation stability and its poor performance under cold climatic condition due to their high viscosity. Due to poor oxidation stability these oils do not remain stable after certain period of time. Further under cold climatic condition the oil particles are solidified and lead to the plugging of fuel filters lines and create fuel starvation problem for the engine. There is therefore need to assess the potentially of SVOs for direct use as well for biodiesel production on the basis of OSI the SVOs with higher OSI, not the one having low OSI can be recommended for biodiesel as the later would require exhaustive and costly attempts for stabilization. The literature reveals that no work is reported on potential assessment of vegetable oils for biodiesel production based on oxidation stability in India. This review work would enable one to select only those oils that have high OSI and recommend them for biodiesel production because the resulting biodiesel would have the stability similar to its parent oil. The work reported would not recommend oils having lower OSI for biodiesel production because the resulting biodiesel will need considerable effort for its stabilization by the addition of costly antioxidants and metals as additives but recommend potential SVOs for biodiesel production based on OSI.

2. Straight vegetable oil (SVO)

The possibilities of using edible oil resources for biodiesel production are remote as the primary need is to meet the food demand of edible oils which are already been imported in India. Further India produces about 9.3% edible oil of world's total oil seed production and fourth largest edible oil producing country in the world and still about 46% of it is imported to meet the domestic needs. Attention has, therefore, been focused to grow oil resources like *Jatropha curcas, Pongamia pinnata, neem, sal, mahua* which may be available for use as SVO for biodiesel production. Vegetable oils are mainly composed of triglycerides consisting of one mole of glycerol linked to three mole of fatty acids having long chain of carbon atoms, with single and double bonds with a carboxyl group. Despite different chemical compositions, SVOs have fuel properties similar to petroleum-diesel making them suitable as fuel for diesel engine. SVOs have several advantages over petroleum fuel viz: (i) local availability, (ii) renewability, (iii) relatively high heating value, (iv) lower sulphur content, with minimum pollution, (v) lower aromatic content and (vi) high biodegradability [7]. Atabani et al. [8] found that there is a huge chance to produce biodiesel from non-edib le oil sources. Li et al. [9] observed the use of SVO reduce particulate emission from diesel engine. Esteban et al. [10] reported that the viscosity of SVO is a major problem in its use as engine fuel. Esteban et al. [11] reported the disadvantages of SVOs like higher kinematic viscosity and surface tension, thereby making their injection and atomization difficult in engine cylinder.

2.1. Vegetable oils as food

Fats and oil are essential component of human and animal diet and provide concentrated source of energy, soluble vitamins and make the food more palatable. The principle source of fats includes vegetable fats and oils, meat, dairy product, fish and nuts. Fatty acids are the building blocks of lipid. Saturated fatty acids, available primarily in product derived from animal sources are used to raise the levels of low density lipoprotein cholesterol in the blood. The unsaturated fatty acid is characterized by the presence of one, two or more double bonds in the carbon chain and are found mostly in plant and sea food. The common vegetable oil like *soybean, sunflower, safflower, mustard, olive, rice bran* being less saturated is considered as “good fats.” These acids are not highly soluble in water, and can be used as energy inside the cells. The main problem of polyunsaturated oil is that they contain extremely fragile and unstable long chain fatty acid. The unsaturated oil in semi-cooked food becomes rancid in just a few hours even when refrigerated. These are responsible for the toxicity of leftover food. As soon as such polysaturated vegetable oils enter into the body, it is exposed to temperature high enough

Table 1
Fuel properties of SVOs [14–20].

Type of oil	Vegetable oils	Specific gravity at 150	Kinematic viscosity (cSt) (38 °C)	Flash point (°C)	Cetane number	Heating values (MJ/kg)	Cloud point (°C)	Pour point (°C)
Edible oils	*Castor*	0.970	29.7	229	51.2	39.5	−11.6	−31.7
	Canola	0.916	20.6	232	40	25	−3.9	−31.6
	Cottonseed	0.914	33.5	234	41.8	39.5	1.7	−15.0
	rapeseed	0.911	37.0	246	37.6	39.7	−3.9	−31.7
	Soybean	0.913	32.6	254	37.9	39.6	−3.9	−12.2
Non-edible oils	*Mahua*	0.880	30.4	226	52.4	41.82	13	15
	Neem	0.961	22.6	175	32	40	22	11
	Jatropha	0.912	55 (30 °C)	240	40–45	39–40	16	–
	Pongamia	0.882	55 (30 °C)	110	51	46	23	–
Petroleum diesel	*Diesel*	0.82–0.86	1.3–4.1	60–80	40–55	42	−15 to −5	−33 to −15